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**HAMPTON UNIVERSITY**

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Director

Submitted to

**NASA MURED  
Partnership Award for the Integration of Research into Undergraduate Education  
PAIR CAN 98-OEOP-1**

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## **Mission**

The mission of CLASS was to provide education and training in NASA-related mathematics, technology and science to U.S. students who are underrepresented in these areas and to encourage them to pursue advanced degrees. The project has three goals which support this mission: research training, curriculum development and outreach.

All project activities are designed to meet a concrete objective which directly advances one of these goals. The common theme of all project activities is NASA's Earth Science Enterprise, in particular, the use of laser-based remote sensing systems (lidars) to monitor and understand the earth's environment.

**Research training** is facilitated through the formation of an undergraduate student team whose activities include:

- in-depth research training in atmospheric science and lidar technology
- interaction with scientists and engineers from NASA, HU, and ITT
- participation in the design, construction, and testing of a state-of-the-art lidar
- joint experiments and subsequent analysis with NASA and ITT using the CLASS lidar

**Curriculum development** is facilitated through:

- faculty development workshops emphasizing modern teaching techniques such as computer based laboratories and NASA-related science
- enhancement of existing courses and development of new courses based on these workshops
- Curriculum assessment instruments

**Outreach** is facilitated through

- Joint experiments, seminars and web-based activities at local high schools and middle schools
- On-campus educational activities at the HU Science Center for K-5<sup>th</sup> grade levels.
- CLASS website and recruitment CD (copy enclosed)

## **Program Goals and Objectives**

Based upon previous NASA reviews, the following activities were added:

- Development of courses in support of a minor in Atmospheric and Space Sciences in order to fully institutionalize the PAIR project,
- Enhancement of existing courses to include NASA-related course content, modernization of teaching equipment and supporting faculty development activities led by an outside curriculum consultant in order to reach a larger number of undergraduate students,
- Consultations with a professional program evaluator to develop and implement a plan for assessing project activities in order to monitor the effectiveness of project activities,
- Involvement of additional K-12 students through outreach activities at the HU Science Center in order to educate more students about NASA-related earth science.
- Increased emphasis on dissemination and recruitment through activities such as the CLASS website and the CLASS -CD [copy enclosed with this report]
- Increased involvement of additional faculty, staff, consultants and students to support these activities.

## Outcomes

### Research Training of Undergraduates:

- A total of 47 posters and presentations were made by students at various conferences.
- Lincoln Haughton (mathematics) won first place in the physical sciences/mathematics category at the 57<sup>th</sup> Annual Meeting of the Beta Kappa Chi Honor Society for his paper.
- Lincoln Haughton (mathematics) was one of 10 students selected nationally by the Council on Undergraduate Research to present at the National Science Foundation.
- Ms. Lena Samuel (biology) won Third Place at the 56<sup>th</sup> Annual Meeting of the Beta Kappa Chi Honor Society for her research paper.
- Mika Edmondson (physics) wrote a computer program, useful to all laser users who need to evaluate potential eyesafety hazards. The program is under evaluation by the university for copyright protection.
- Mika Edmondson (physics), Kyle Lewis (EE), Demetra Johnson (Chem E) and Russell Battle (EE) have been summer student interns at ITT Industries, Systems Division, to develop lidar instruments.



Mr. Russell Battle soldering electrical connections in the CLASS lidar system.

### Curriculum Development

- A minor program in Atmospheric and Space Sciences is being implemented in conjunction with the Hampton University Center for Atmospheric Sciences, with additional leveraged funding through NASA's Office of Space Science,
- Enhancements to introductory physics, introductory physical science and chemistry courses, affecting 300 students per semester, were implemented in the fall of 2000.

### Outreach

- Over 600 middle school students participated in activities related to the earth's environment
- 83 high school students attended seminars on atmospheric science and performed hands-on laser experiments.

## Partnerships

**Crittenden Middle School** students (~90 each year) participated in workshops and web-based projects on the health effects of air pollution, optics, atmospheric science and atmospheric measurements in support of their State Standards of Learning (SOL). **Warwick High School** students (~30/yr) participated in workshops and experiments in optical physics and in atmospheric remote sensing projects, in support of their SOL.

**ITT Industries, Advanced Engineering and Sciences Division** mentored students in their lidar design, fabrication, and testing through teleconferences and provided engineering services and student training in lidar measurements at HU. ITT hosted the CLASS summer industrial internship program, providing hands-on training, professional mentors, laboratory space and equipment, and office support (in kind support from ITT is ~\$30,000/yr). This enabled HU to leverage an additional \$8,000/year from the Virginia Space Grant Consortium to help support this internship program. With a letter of support and \$10,000 matching funds from ITT, a proposal to the Air Force Office of Sponsored Research was awarded to HU for \$185,000 for laser development leading to a greatly improved laser source for the CLASS lidar system and for the HU ozone lidar system.

**NASA Langley Research Center** provided technical advice and support to all aspects of the CLASS project. Members of the Aerosol Research Branch in the Atmospheric Sciences Division and the Laser Systems Branch were active in the program. Seminars were presented by NASA speakers to HU students and faculty on atmospheric science and lidar technologies.

**Center for Atmospheric Sciences (CAS)** at HU provides expertise in lidar techniques and atmospheric science. Its faculty played a critical role in supporting CLASS student research projects and in teaching related courses.

Through an Office of Space Science/MURED award (\$250,000/yr for 3 years) additional teaching and research faculty were hired and a new curriculum was established consisting of 6 courses as a minor in Atmospheric and Space Sciences. Faculty from CAS presented seminars at faculty development workshops. Representatives from all these partnering institutions serve on the CLASS Project Advisory Board.



Mr. Mika Edmondson and Mr. Kyle Lewis are shown training on a lidar system during the 1999 summer internship



Ms. Demetra Johnson working on the CLASS lidar system during her 2000 summer internship at ITT



Dr. Ali Omar conducts a workshop at Crittenden Middle School.

The close collaboration between NASA, ITT and HU has facilitated exchange of technical information and discussion of common problems among the three organizations. For example:

- Joint development and use of software for the evaluation of laser eyesafety hazards
- Joint development of software to model lidar performance
- Joint development of software for instrument control and data analysis
- Joint research projects into more efficient and compact laser sources for eyesafe applications
- Joint research projects to investigate common technical problems such as the short range reduction in efficiency of the lidar system.

The partnerships resulted in the following unexpected outcomes:

- A technology disclosure form was submitted to HU for copyright protection for a computer program which greatly simplifies laser eyesafety calculations for laser users. This program was developed jointly by CLASS faculty and students and ITT scientists. Demonstration copies have been made available to NASA scientists for their use. One commercial company, specializing in technical software, has expressed interest in the program. When disseminated, this software brought additional attention to the project. Mika Edmondson's expertise in scientific calculations using Mathcad contributed to his being accepted in the University of Rochester REU/McNair Program (summer 2000).
- The unique capabilities of the lidar system, jointly developed with NASA and ITT, have generated interest from the pollution- monitoring community and NASA. The project was able to partner with NASA and other organizations, and to write more proposals for follow-on funding to sustain the CLASS program after the 5<sup>th</sup> year.
- Seniors from Warwick High School performed research projects at HU.
- A Ph.D. research project concerned with short range efficiency of lidar systems such as the CLASS system. led to increased graduate student involvement in the project and additional publications and presentations.
- The development of a complete minor program in Atmospheric and Space Sciences was not anticipated in the original proposal. This was a major step in institutionalizing the project at Hampton University.

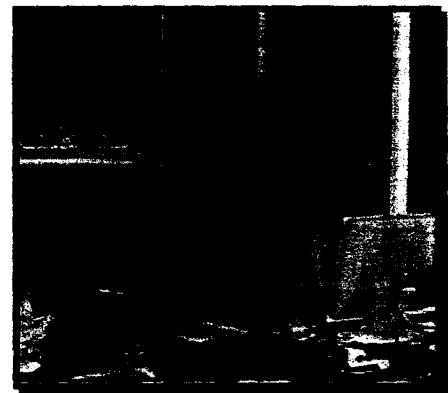


Ms. Anne Futrell showing the Review Team members the laser demonstration setup used in the Warwick high school workshops.

## **Integration of Research and Research Training in Undergraduate Studies**

NASA-related research has been integrated into the MSET curriculum in three major ways:

- Research projects for research credit to satisfy requirements for student majors, scholarships, capstone theses, or research papers or other core course requirements.
- Enhancement of existing courses to incorporate NASA-related content or techniques. An example of this is the incorporation of NASA- related projects using a new microcomputer-based laboratory experiments and data analysis were integrated into the Physics 215 and 216 (Introductory Physics Laboratory). 100% of the students in science and engineering take these courses.
- Development of new courses (forming a minor program in Atmospheric and Space Sciences) which incorporate NASA-related research.



Mr. William Watson conducts a computer interactive module in the Introductory Physics laboratory.

Courses which incorporated NASA-related research and technology and CLASS research projects have enhanced the undergraduate student experience in the following ways:

- Provided students an educational background in NASA-related science on which to base their research project
- Provided the students with a continuous, multiyear research project supervised by a scientist or engineer mentor
- Made the student ultimately responsible for progress on the project, offering them the opportunity to present research papers and to use the project as the focus for research credit or to fulfill major requirements.
- Provided opportunities to discuss their project with scientists from NASA and industry.
- Provided practical experimental and computational experience, making the students more attractive to future employers and graduate schools.

A specific example of this is the case of Mika Edmondson, a senior physics major. As a sophomore, Mika entered the CLASS project. He learned about lidar and eyesafety issues at the CLASS student meetings in the fall. In the spring, he took the Atmospheric Science course and Experimental Physics I. The latter course was enhanced to include new hands-on experiments with optics, aligning lasers and computerized data analysis and calculations with Mathcad. He started working on his CLASS research project —eyesafety calculations with Mathcad. The NASA Langley laser safety officer provided the American National Standards Institute eyesafety documentation. This experience made him a prime candidate for the 1999 summer internship program at ITT in which he did optical experiments as well as continued his Mathcad program under the mentorship of ITT engineers and HU faculty. Computations performed with his program were shown to agree with those performed by the NASA Langley Laser Safety Officer using current laser safety programs. In the fall of 1999, copies of his program were requested by NASA scientists at the Annual Research Center for Optical Physics Site Visit. Further refinements to the program were made and a Technology Disclosure Form was filed with the Hampton University Office of Sponsored Programs in order to evaluate if copyright protection is warranted. A commercial corporation expressed interest in learning more about the program to evaluate its marketability. Mika presented the results of his research at several science conferences. This persistent research experience with computerized mathematical calculations enabled Mika to be accepted for the summer 2000 University of Rochester REU/McNair program, during which time he worked on Mathcad models of planet temperatures for various stars and attended seminars to assist him in pursuing his graduate career.

The faculty teaching experience was enhanced by the following:

- Rejuvenation of existing courses through faculty development workshops geared to incorporating state-of-the-art teaching and assessment techniques and NASA-related content,
- Opportunity and resources to develop NASA-related research projects with students in their existing courses,
- Opportunity to present the results of their research at conferences and to establish ties with other researchers.

Example: Chem 201-202 (Dr. Grace Ndip): Incorporation of Earth Science content, state of the art interactive chemistry software into the course, acquisition of equipment to measure pH (acidity) and a computer for data analysis. These enhancements will also enable Dr. Ndip to initiate long-term student research projects to investigate the acidity of local rivers due to acid rain production in the atmosphere.

In addition, the following student outcomes provide evidence that the project has had a positive impact upon their education and competitiveness for graduate school:

- Lincoln Haughton (mathematics) won first place in the physical sciences/mathematics category at the 57<sup>th</sup> Annual Meeting of the Beta Kappa Chi Honor Society for his paper.
- Ms. Lena Samuel (biology) won 3rd Place at the 56<sup>th</sup> Annual Meeting of the Beta Kappa Chi Honor Society for her research paper.
- Mika Edmondson (physics) wrote a computer program, useful to all laser users, which is under evaluation by the university for copyright protection.
- Lincoln Haughton (mathematics) was one of 80 students invited by the Council on Undergraduate Research to present his work in a poster session on Capitol Hill in 1999.
- Lincoln Haughton (mathematics) was one of 10 students selected nationally by the Council on Undergraduate Research to present at the National Science Foundation.



Mr. Haughton at his poster presentation at the National Council for Undergraduate Research, attended by faculty and students nationwide.

## Publications and Presentations

### Publications

1. Payne-Baggott, R., T. H. Chyba and D. Richter, Optical Design of the Hampton University Lidar Systems," Optical Remote Sensing of the Atmosphere, OSA Technical Digest, (OSA, Washington DC, 2001) 41-42.
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6. K. Lewis, W. Gong, D. A. Temple, A. H. Omar, J. Mangana, "Development of A 3-D Scanning 1.5 $\mu$ m Portable Aerosol Lidar", 2002 IEEE Technical Digest, 0-7803-7537-8/02, IGARSS (2002).
7. L. Williams, W. Gong, D. A. Temple, A. H. Omar and J. Mangana, "An Aerosol Lidar Model Program used for the Center for Lidar and Atmospheric Sciences Students Lidar system", 2002 IEEE Technical Digest, 0-7803-7537-8/02, IGARSS (2002).
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3. Temple, D. A., and T. H. Chyba "The CLASS Project," National Council of Undergraduate Research Annual Meeting, Missoula, Mt., April 28, 2000.
4. Chyba, T. H., D. A. Temple, S. Bailey, A. Bowman, A. Omar, B. Bradley, M. Edmondson, A. Futrell, C. Glenn, D. Harper, L. Haughton, S. Lee, K. Lewis, C. Meyer, R. Patterson, R. Payne, K. Reaves, L. Samuel, L. Williams, N. S. Higdon and D. A. Richter, "The Center for Lidar and Atmospheric Sciences Students Scanning Aerosol Lidar," 20<sup>th</sup> International Laser Radar Conference, Vichy, France, July 10-14, 2000, poster.
5. Temple, D. A., and T. H. Chyba "The CLASS Project," NASA MUSPIN 10<sup>th</sup> Annual Conference, Atlanta, Ga., Sept. 11-14, 2000 (invited oral paper and poster).

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8. Bradley, B., L. Haughton, Kyle Lewis, K. Johnson, L. Samuel, K. Mims, T. Robinson-Brown, M. Edmondson, R. Payne, "The CLASS Aerosol Lidar Project," 4th. Annual HU Science Research Symposium, Feb. 13, 1999. Poster presentation.
9. Haughton, L., "Mathematical Modeling of an Aerosol Lidar System," 4th. Annual HU Science Research Symposium, Feb. 13, 1999. Poster
10. Haughton, L., "Mathematical Modeling of an Aerosol Lidar System," Oral Presentation at the CLASS Advisory Board Meeting, March 15, 1999.
11. Haughton, L., "Mathematical Modeling of an Aerosol Lidar System," Council on Undergraduate Research Meeting on Capitol Hill, Washington D.C., April 15, 1999, poster presentation.
12. Haughton, L., "Mathematical Modeling of an Aerosol Lidar System," Council on Undergraduate Research Meeting at the National Science Foundation, Washington D.C., April 17, 1999, poster presentation.
13. Samuel, L., A. Omar, T. H. Chyba, and D. Temple, "The CLASS - Crittenden Middle School (CLASS-CMS) study of local air quality" 4th. Annual HU Science Research Symposium, Feb. 13, 1999. Poster presentation.
14. Samuel, L., "The CLASS - Crittenden Middle School (CLASS-CMS) study of local air quality" Sigma Xi Scientific Research Society, Old Dominion University, Norfolk, Virginia, April 2, 1999, poster presentation..
15. Samuel, L., "The CLASS - Crittenden Middle School (CLASS-CMS) study of local air quality" Beta Kappa Chi Scientific Honor Society, Oklahoma City, Oklahoma, April 1-4, 1999, poster presentation.
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17. Lewis, K. M., "Lidar Receiver Design and Evaluation," ITT Summer Internship Seminar, ITT Industries, Albuquerque, Nm., July 29, 1999.
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24. Edmondson, M., T. H. Chyba, N. S. Higdon and D. A. Richter, "Laser Eyesafety Calculations for Lidar Systems," 5<sup>th</sup> Annual Hampton University Student Research Symposium, Hampton, Va., February 5, 2000.
25. Haughton, L., A. Futrell, D. A. Temple, and T. H. Chyba "Mathematical Modelling of an Aerosol Lidar System," 5<sup>th</sup> Annual Hampton University Student Research Symposium, Hampton, Va., February 5, 2000.
26. Lewis, K., R. Patterson, K. Reaves, B. Bradley, D. A. Temple, and T. H. Chyba "Data Acquisition, Analysis and Storage in an Aerosol Lidar System," 5<sup>th</sup> Annual Hampton University Student Research Symposium, Hampton, Va., February 5, 2000.
27. Meyer, C., A. Bowman, A. Omar, D. A. Temple and T. H. Chyba, "Health Effects of Fine Particle Pollution," CLASS Site Visit, Hampton University, Hampton, Va., February 10, 2000.
28. Samuel, L., C. Meyer, A. Bowman, A. Omar, D. A. Temple and T. H. Chyba, "The CLASS-CMS Study of Local Air Quality and Health Effects of Air Pollution," CLASS Site Visit, Hampton University, Hampton, Va., February 10, 2000.
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32. Haughton, L., A. Futrell, D. A. Temple, and T. H. Chyba, "Mathematical Modelling of an Aerosol Lidar System," CLASS Site Visit, Hampton University, Hampton, Va., February 10, 2000.
33. Edmondson, M., D. A. Temple, T. H. Chyba, N. S. Higdon and D. A. Richter, "Laser Eyesafety Calculations for Lidar Systems," CLASS Site Visit, Hampton University, Hampton, Va., February 10, 2000.
34. Payne-Baggott, R., T. H. Chyba and D. Richter, "Receiver Development for the Hampton University Aerosol and Ozone Lidar Systems using ZEMAX Optical Design Software," Virginia Space Grant Consortium Student Research Conference, NASA Langley Research Center, Hampton, Va., March 24, 2000.
35. Haughton, L., D. A. Temple and T. H. Chyba, "Mathematical Modelling of an Aerosol Lidar System," Senior Mathematics Seminar, Hampton University, Hampton, Va., April 4, 2000.
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38. Haughton, L., D. A. Temple and T. H. Chyba, "Mathematical Modelling of an Aerosol Lidar System," Beta Kappa Chi 57<sup>th</sup> Annual Meeting , Nashville, TN. April 7, 2000.
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